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(54) Title: METHOD OF FORMING AN ALUMINUM OXIDE FILM

(57) Abstract

The present invention relates to a method of forming an aluminum oxide film for use in semiconductor devices on a substrate. Organo-aluminum compound and alcohol, which are sources for the aluminum oxide film formation, are first prepared as gas phases, respectively. Then the gas phase sources are sequentially applied to the substrate to form an aluminum oxide film. In general, alcohol can be evacuated faster than water vapor in a vacuum chamber, which significantly reduces time required for source supply cycle. Therefore, according to the present invention, the growth rate of the aluminum oxide filmn can be increased compared with prior art methods. In addition, the cost associated with semiconductor device fabrication can be reduced because the temperature of both gas supply unit and a reactor can be decreased.

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METHOD OF FORMING AN ALUMINUM OXIDE FILM

TECHNICAL FIELD

The present invention relates to a method of forming an aluminum oxide film, and more particularly to a method of forming an aluminum oxide film on a substrate for semiconductor devices.

BACKGROUND ART

Aluminum oxide film is well known to be used widely not only for optical purposes but also for protection films, gate oxide films and optical lithography masks for semiconductor devices as shown in the reference 1. (reference 1: E. Fredriksson and J.O. Carlsson, *Journal of Chemical Vapor Deposition*, vol. 1, p. 333 (1993)) Furthermore, reference 2 reported the use of aluminum oxide film for protection from hydrogen diffusion by forming an ultra-thin aluminum oxide film on a PZT($PbZrTiO_3$) dielectric layer of a FeRAM(Ferroelectric Random Access Memory) (reference 2: Sang Min Lee, Young Kwan Park, In Son Park, Chang Soo Park, Cha Young Ryu, Sang In Lee, Mun Yong Lee, *Abstract of the 5th Korean Semiconductor Society* p. 255 (1998)).

Compared to the conventional chemical vapor deposition method which provides source materials of a thin film simultaneously, the sequential supply of source materials on a substrate can form a thin film only by a chemical reaction on a substrate surface. Therefore, the latter method can grow a thin film of uniform thickness irrespective of uneven substrate surface, and can control precisely film thickness because the growth of film depends not on process time but on the number of source material supply cycles. It is well described in the "Atomic Layer Epitaxy" edited by T. Suntola and M. Simpson (reference 3: T. Suntola and M. Simpson eds. *Atomic Layer Epitaxy*, Blackie, London (1990)).

As an application of the latter method, the formation of aluminum oxide film having a uniform thickness on an uneven substrate surface by a sequential supply of trimethylaluminum and water vapor was proposed in the reference 4. (reference 4: Y. Kim, S. M. Lee, C. S. Park, S. I. Lee, and M. Y. Lee, *Applied Physics Letters*, vol. 71, p. 3604 (1997)). Referring to the reference 4, trimethylaluminum, argon, water vapor

and argon are sequentially supplied for 1, 14, 1, and 14 seconds, respectively in each cycle while keeping the substrate at a temperature of 370°C in a reactor heated at 150°C. In each source material supply cycle, the film grows by 0.19nm which makes the total film growth rate of 0.38nm/min. This growth rate is too slow to be applied to semiconductor device fabrication. In order to enhance the film growth rate, each source material supply cycle should be shortened. In the technology disclosed in the reference 4, water vapor is used in the film growth. However, the water vapor is difficult to evacuate in a vacuum chamber, which makes the decrease of material supply cycle time difficult.

Furthermore, in case of using water vapor for the formation of an aluminum oxide film, the reactor and the gas supply unit where the water vapor passes should be kept at high temperature because water vapor is easily condensed in a cold unit. It increases energy consumption and workers may get burned during the operation and maintenance of the equipment.

DISCLOSURE OF INVENTION

Accordingly, it is an object of the present invention to provide a method of forming an aluminum oxide film by employing source materials which can be easily evacuated in a vacuum chamber and are less susceptible to condense in a reactor.

It is another object of the present invention is to provide a method which can form an aluminum oxide film faster than the method which employs water vapor.

In order to achieve the above objects, the method of forming an aluminum oxide film of the present invention comprises the steps of: preparing gases of organo-aluminum compound and alcohol for forming an aluminum oxide film; and contacting said gases sequentially and repeatedly onto a substrate.

The number of carbons in the alcohol molecule is preferably from 2 to 6, and more preferably the alcohol is isopropanol which is widely used in the semiconductor device fabrication.

Furthermore, the organo-aluminum compound is preferably trialkylaluminum, and more preferably the trialkylaluminum is trimethylaluminum.

BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiment of the present invention will be described below.

First of all, trimethylaluminum and isopropanol are gasified and are supplied into a deposition chamber. Argon gas is provided as a purge gas between the supplies of the gasified trimethylaluminum and isopropanol. Because isopropanol has a high vapor pressure, it is supplied into the reactor directly using a carrier gas without an additional heating process. Trimethylaluminum gas, argon purge gas, isopropanol gas and argon purge gas are sequentially supplied for 2, 2, 2 and 2 seconds, respectively in each cycle which makes the gas supply period of 8 seconds. The trimethylaluminum decomposes above 300°C, so the source materials must be supplied at a temperature lower than 300°C to grow a film only by a surface reaction. When the film is grown on a substrate kept at 250 ~ 290 °C, the film growth rate by measuring the film thickness using an ellipsometer is determined to be 0.08nm per source material supply cycle or 0.60nm/min.

INDUSTRIAL APPLICABILITY

According to this invention, the temperature for gas supply unit and a reactor can be lowered compared to the previous methods. It can, therefore, simplify apparatus necessary for fabricating semiconductor devices and lower manufacturing cost. Furthermore, an aluminum oxide film with superior step coverage can be grown faster than prior art methods.

WHAT IS CLAIMED IS :

1. A method of forming an aluminum oxide film comprising the steps of:

preparing gases of organo-aluminum compound and alcohol for forming an aluminum oxide film; and

contacting said gases sequentially and repeatedly onto a substrate.

2. The method according to claim 1, wherein the number of carbons in said alcohol molecule is from 2 to 6.

3. The method according to claim 2, wherein said alcohol is isopropanol.

4. The method according to any of claims 1 to 3, wherein said orgoano-aluminum compound is trialkylaluminum.

5. The method according to claim 4, wherein said trialkylaluminum is trimethylaluminum.

6. The method according to claim 1, wherein the temperature of substrate is kept at 250 ~ 290°C at the step of contacting said gases sequentially and repeatedly onto a substrate.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR00/00204

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01L 21/316

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 H01L 21/316

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applicatins for inventions since 1975
Korean Utility models and applicatins for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
D, A	Applied Physics Letters, Vol 71, Page 3604, 1997	1, 5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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